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Deposit thickening with distance on flat topographies: the role of hindered settling

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Deposits of turbidity currents have several features still not well understood. For example, the small rate of thinning with distance of natural scale deposits, which does not follow the typical exponential decay, and a thickening with distance observed of some turbidites. In this paper we focus our attention on the latter feature. Instead of having a constant decay in the deposition thickness, the turbidite shows that after an initial short thinning, the deposit thickens with distance up to a maximum, then the deposit begins to thin again. This feature has been found in nature even over flat topographies. This thickening occurs in flows whose length increases with distance and at the same time, the concentration of solids reduces with time, due to both deposition and the expansion of the flow. We found mathematically, that this effect can only occur on non-homogeneous flows. We show that the hindered settling velocity plays a key role in this phenomenon, even in dilute flows. The reduction of the terminal settling velocity due to the presence of other particles, together with turbulence, enhances the development of vertical and horizontal concentration gradients along the body of the flow, which affects the resulting deposit patterns.

In order to improve the understanding of the dynamics of the flows that produce these deposition patterns, we developed a program to solve the full Navier-Stokes equations for two phase dilute flows in 2D. The program was tested with raw data from channel lock experiments, showing an excellent statistical agreement in the prediction of the front position, internal velocity distribution and deposit patterns. By modelling lake scale flows, the program reproduced the thickening with distance found in natural scale flows. It predicts that after the release of a homogeneous flow, the material is initially deposited with a constant decay rate. As the flow becomes non-homogeneous, turbulence and concentration gradients develop, and at the same time the flow body lengthens, thus the amount of deposited material at a given point increases in relation to the previous stage, resulting in a thickening with distance. The passage time of the body of the flow increases at a given point in proportion to the distance of the point. As the distance increases, the passage time becomes larger. However, the more distant the point is, the lower the deposition rate will be. This deposition rate is not constant along all the passage time, as the flow is not homogeneous. Peaks in the deposition rate are predicted by the program. These peaks tend to disappear after the passage time is balanced with a low deposition rate. The maximum deposition thickness occurs at this moment. We show that a slope change is not a necessary condition to produce a thickening with distance, but the hindered settling and its enhancing effect in the development of non-homogeneous flows is.